

What is claimed is:

### **CLAIMS**

1. A diagnostic tool for testing fuel injectors and their driver circuits in a fuel injection system of an engine in a motor vehicle, the tool comprising:

a driver-connection port for connection to the driver circuits;

an injector-connection port for connection to the fuel injectors;

a load that simulates a load imposed by a fuel injector on a driver circuit;

individual position selector switches each of which is individual to a particular fuel injector and the respective driver circuit and is selectively operable to:

a) a first position that connects the simulated load through the driver-connection port to the respective driver circuit when the driver circuits have been disconnected in the vehicle from the fuel injectors and instead connected to the driver-connection port; and

b) a second position that connects the respective driver circuit through the tool with the respective fuel injector when the driver circuits and the fuel injectors have been disconnected in the vehicle from each other, the driver circuits are instead connected to the driver-connection port, and the fuel injectors are instead connected to the injector-connection port.

2. A diagnostic tool as set forth in Claim 1 wherein each position selector switch is further operable to a third position that disconnects the respective driver circuit from both the simulated load and the respective fuel injector when the driver circuits and the fuel injectors have been disconnected in the vehicle from each other, the driver circuits are connected to the driver-connection port, and the fuel injectors are connected to the injector-connection port.

3. A diagnostic tool as set forth in Claim 1 further including an indicator that illuminates when the simulated load is being energized by a driver circuit.

4. A diagnostic tool as set forth in Claim 3 wherein the simulated load comprises two individual simulated loads per fuel injector, each of which individual simulated loads is connected to a respective driver circuit when the driver circuits are connected to the driver-connection port and the respective position selector switch is in its first position, and the indicator comprises a respective indicator light that illuminates when the respective individual simulated load is being energized by the respective driver circuit.

5. A diagnostic tool as set forth in Claim 1 further including, for each fuel injector, a respective sensor for sensing magnetic flux created by flow of electric current from a respective driver circuit through the tool to the respective fuel injector when the respective position selector switch is in the second position, and a respective indicator that illuminates when the magnetic flux sensed by the respective sensor is indicative of the delivery of a particular electric current from the respective driver circuit to the respective fuel injector.

6. A diagnostic tool as set forth in Claim 5 including an auxiliary-equipment-connection port for connecting auxiliary test equipment to the tool, an injector-selector switch that is operable to select a particular one of the fuel injectors, and for each fuel injector, a respective sensor through which a signal indicative of flow of electric current through the tool to the respective fuel injector from the respective driver circuit is conveyed to the auxiliary-equipment-connection port when the injector-selector switch is selecting that particular fuel injector and the respective position selector switch is in the second position.

7. A diagnostic tool as set forth in Claim 6 including an additional auxiliary-equipment-connection port for connecting auxiliary test equipment to the tool, and a sensor for delivering to the additional auxiliary-equipment-connection port, a signal indicative of flow of electric current through the tool to a fuel injector from the respective driver circuit when the respective position selector switch is in the second position.

8. A diagnostic tool as set forth in Claim 1 including an auxiliary-equipment-connection port for connecting auxiliary test equipment to the tool, and an injector-selector switch that is connected between the injector-connection port and the auxiliary-equipment-connection port and that is operable to select a particular one of the injectors for direct connection to the auxiliary-equipment-connection port.

9. A diagnostic tool as set forth in Claim 8 wherein the auxiliary-equipment-connection port comprises first and second terminals, and the injector-selector switch, when selecting a particular fuel injector, electrically connects a respective terminal of the selected fuel injector directly to a respective one of the first and second terminals of the auxiliary-equipment-connection port.

10. A diagnostic tool as set forth in Claim 9 including an additional auxiliary-equipment-connection port that comprises its own first and second terminals, and wherein the injector-selector switch, when selecting a particular fuel injector, electrically connects a respective one of four terminals of the selected fuel injector directly to a respective one of the four terminals of the auxiliary-equipment-connection ports.

11. A diagnostic tool for testing a fuel injector and a respective driver circuit in a fuel injection system of an engine in a motor vehicle when the driver circuit and the fuel injector have been disconnected from each other in the vehicle and instead connected to the tool, the tool comprising:

- a driver-connection port for connection of the driver circuit to the tool;
- an injector-connection port for connection of the fuel injector to the tool;
- an electric current path through the tool for conducting electric current from the driver circuit to the fuel injector;

- a sensor for sensing magnetic flux created by flow of electric current through the current path; and

- an indicator that illuminates when the magnetic flux sensed by the sensor is indicative of the delivery of a particular electric current from the driver circuit to the fuel injector;

wherein the sensor comprises an electronic circuit chip disposed proximate at least one turn of a conductor of the current path that effectively amplifies the density of magnetic flux that results from the flow of electric current through the current path, and the indicator comprises a light-emitting diode that is operated by the chip to illuminate when the magnetic flux acting on the sensor exceeds an amount that indicates the particular electric current flow from the driver circuit to the fuel injector.

12. A diagnostic tool for testing fuel injectors and driver circuits that operate the fuel injectors in a fuel injection system of an engine in a motor vehicle when the driver circuits and the fuel injectors have been disconnected from each other in the vehicle and instead connected to the tool, the tool comprising:

- a driver-connection port for connection of the driver circuits to the tool;
- an injector-connection port for connection of the fuel injectors to the tool;

a respective electromagnetic sensor for sensing flow of electric current from each driver circuit through the tool to a respective fuel injector;

a first auxiliary-equipment-connection port for connecting an oscilloscope to the tool;

an injector-selector switch for selectively connecting the electromagnetic sensors to the first auxiliary-equipment-connection port;

a second auxiliary-equipment-connection port for connecting an oscilloscope to the tool; and

an electromagnetic sensor connected to the second auxiliary-equipment-connection port for sensing flow of electric currents from multiple ones of the driver circuits to their respective fuel injectors.

13. A diagnostic tool as set forth in Claim 12 wherein the electromagnetic sensor connected to the second auxiliary-equipment-connection port is disposed to sense flow of electric currents from all of the driver circuits to their respective fuel injectors.

14. A diagnostic tool as set forth in Claim 12 including a position selector switch for selectively connecting and disconnecting each driver circuit to and from the respective fuel injector.

15. A diagnostic tool for testing of fuel injectors and their driver circuits in a fuel injection system of an engine in a motor vehicle when the driver circuits and the fuel injectors have been disconnected from each other in the vehicle and instead connected to the tool, the tool comprising:

a driver-connection port for connection of the driver circuits to the tool;

an injector-connection port for connection of the fuel injectors to the tool;

switches that allow the driver circuits to be individually selectively connected and disconnected, through the tool, to and from the fuel injectors.

16. A diagnostic tool as set forth in Claim 15 including an indicator that is associated with an actuator of each fuel injector and that illuminates when the respective driver circuit is delivering current to the associated actuator.

17. A diagnostic tool as set forth in Claim 15 including a firing order table for correlating the tool with any one of multiple engine models comprising indicia correlating each switch with the correct cylinder in each particular engine model.

18. A diagnostic tool for testing fuel injectors and their driver circuits in a fuel injection system of an engine in a motor vehicle when the driver circuits and the fuel injectors have been disconnected from each other in the vehicle and instead connected to the tool, the tool comprising:

a driver-connection port for connection of the driver circuits to the tool;  
 an injector-connection port for connection of the fuel injectors to the tool;  
 auxiliary-equipment-connection ports that allow connection of auxiliary test equipment to the tool;

a load that simulates the load imposed by a fuel injector on a driver circuit;  
 multiple indicators;

switches that allow the driver circuits to be selectively connected and disconnected, through the tool, to and from the fuel injectors, and that

a) when disconnecting a driver circuit from a respective fuel injector, connect that driver circuit to the simulated load to enable a driver circuit test to be performed with the result being indicated by one of the indicators,

b) when disconnecting a driver circuit from a respective fuel injector, connect a fuel injector to one of the auxiliary-equipment-connection ports to enable a fuel injector test to be performed via a piece of test equipment connected to that one auxiliary-equipment-connection ports; and

c) when connecting a driver circuit to a respective fuel injector, enable a driver-injector test to be performed with the result being indicated by a respective indicator, and with a waveform of electric current flow from the driver circuit to the fuel injector being made available to another piece of test equipment connected to another of the auxiliary-equipment-connection ports.

19. A method for conducting diagnostic testing of fuel injectors and their driver circuits in a fuel injection system of an engine in a motor vehicle, the method comprising:

disconnecting mated connections between the driver circuits and the fuel injectors;

connecting the driver circuits to a driver-connection port of the tool;

connecting the fuel injectors to an injector-connection port of the tool;

conducting at least one of the following tests comprising:

a) a fuel injector test, by connecting a piece of test equipment that measures an electrical characteristic of an electric actuator of a fuel injector to an auxiliary-equipment-connection port of the tool, and operating switches of the tool to disconnect the actuator of the fuel injector from the respective driver circuit and to instead connect the actuator to the auxiliary-equipment-connection port;

b) a driver-injector test, by connecting an oscilloscope to an additional auxiliary-equipment-connection port of the tool, and operating the switches of the tool to connect the fuel injector actuator to the respective driver circuit and to connect to the additional auxiliary-equipment-connection port, a sensor that senses the electric current flow from the respective driver circuit to the fuel injector actuator;

c) a driver circuit test, by operating the switches of the tool to disconnect the actuator of the fuel injector from the respective driver circuit and to instead connect the respective driver circuit to a load that simulates the load imposed by the respective fuel injector; and

d) a cylinder contribution test, by operating the switches of the tool to connect each fuel injector actuator to its respective driver circuit, and then selectively operating the switches to selectively disconnect certain fuel injector actuators from their driver circuits while leaving the remaining fuel injector actuators connected to their driver circuits.

20 . A method as set forth in Claim 19 wherein the fuel injector test, the driver-injector test, and the driver circuit test are all performed.

21. A method as set forth in Claim 19 wherein the fuel injector test comprises connecting a volt-ohmmeter as the piece of test equipment that measures an electrical characteristic of an electric actuator of a fuel injector to the auxiliary-equipment-connection port.